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THE IMPORTANCE OF THICK SEEDING IN THE PRODUCTION OF MILO IN THE SAN ANTONIO REGION.[1]

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INTRODUCTION.

One of the most important needs in the agriculture of the San Antonio region of Texas is a dependable grain crop. For a number of years, corn was generally looked upon as the best grain crop for the region, but it has not proved to be dependable. The small grains are even less satisfactory. Because of the difficulties and failures of local grain production, it has been necessary to import a large proportion of the grain needed for local consumption.

Experiments have been conducted for several years at the San Antonio Experiment Farm to determine whether or not the grain sorghums could be depended upon to increase the local supply, as well as to give some stability to local production. The two principal grain crops of the region are oats and corn. The average yields per acre of oats and corn from the rotation experiments for the past six years and of early-planted grain sorghum (milo) for the past four years at the San Antonio Experiment Farm are shown in Table I.

Table I.—*Average yields of oats, corn, and milo at the San Antonio Experiment Farm for the years 1909 to 1914, inclusive.*

Year.	Yield per acre (bushels).			Year.	Yield per acre (bushels).		
	Oats.	Corn.	Milo.		Oats.	Corn.	Milo.
1909	....	9.8	....	1912	26.75	34.1	40.0
1910	10.70	8.0	....	1913	11.70	34.9	47.7
1911	8.50	10.6	32.0	1914	15.70	52.6	43.2

These figures indicate that, in the main, milo gives larger yields and is more dependable than either oats or corn. The average yield per acre of oats for the past four years, 1911 to 1914, was 15.7 bushels; of corn, 33.1 bushels; while the average yield of milo for the same period was 40 bushels. The last three years have been unusually favorable for corn production and the yields were considerably higher than may be expected, as the average yield for the past eight

[1] The experiments were conducted in cooperation with the Office of Cereal Investigations.

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years, 1907 to 1914, inclusive, was only 24.4 bushels per acre. It is during years when the rainfall is low that milo shows a marked superiority over corn and oats, and it is probable that the figures given above do not do justice to milo. The results obtained at the experiment farm and by farmers who have given the crop a fair trial indicate that grain sorghum can be made a highly satisfactory grain crop in the San Antonio region if the proper varieties are grown and the necessary cultural methods are followed.

CAUSES OF UNSATISFACTORY YIELDS.

SORGHUM MIDGE AND THIN STANDS.

One of the chief difficulties encountered in the production of the grain sorghums in the vicinity of San Antonio has been the sorghum midge. It has been found, however, that by using reasonably quick-maturing varieties and planting them early a good crop can be produced before the midge appears in sufficient numbers to do serious damage. This matter has already been made the subject of a publication.[1]

There are still numerous instances in which the yields have been low on certain farms. From the observations made on these farms, and also at the experiment farm, it appears that unsatisfactory yields are due, in many instances, to thin stands. Thin stands frequently result from thin seeding, which the farmers practice in the belief that with the low rainfall of the region thick seeding is not advisable. In this section thin stands permit excessive tillering or branching of the plants, and this results in delayed and nonuniform maturity. The thin stands and unsatisfactory maturity appear to be chiefly responsible for the low yields.

The tillers and branches of sorghum plants flower and mature later than the main stalks. The successful production of sorghum in the midge-infested regions depends upon the crop getting past the flowering stage before the midge appears. Earliness is of prime importance. As is shown in the results obtained in 1913, there may be years when there will be no great increase in yield from thick seeding. This was due to the fact that even the late-flowering heads were mature before the midge appeared. On the other hand, when, because of unfavorable weather conditions or for other reasons, planting is so delayed that the crop is in flower at about the time the midge appears, as was the case in 1914, uniform flowering is of prime importance if good yields are to be expected.

TILLERS AND BRANCHES.

All sorghums, when widely spaced in the row, produce an abundance of tillers and less frequently branches under the same conditions. Tillers are produced at or near the surface of the ground and appear when the plant has reached a height of only a few inches, but their

[1] Ball, C. R., and Hastings, S. H. Grain-sorghum production in the San Antonio region of Texas. U. S. Dept. of Agriculture, Bureau of Plant Industry Bulletin 237, 30 p., 1912.

appearance may be delayed until the plant is 18 inches or more in height. Tillers seldom appear after the stems of the plants have begun to develop, particularly if the plants are left close enough together to shield the lower parts from the light. The development of tillers is largely controlled by the distance apart of the plants and, to a lesser extent, by the soil and climatic conditions. Tillers have small heads and are later in maturing than the main stalk.

Branches indicate abnormal conditions and do not appear until the plant is well along in its growth. They occur only when the plants are spaced too far apart in the row or are supplied with an abundance of moisture. Every node above the ground except the terminal node may produce branches. The heads of the branches are still smaller and later in maturing than those of the tillers.

Branching is even more objectionable than tillering, as the ripening season is still further extended. Branches occur in abundance only when the plants are too far apart in the row and the temperature and moisture conditions are exceptionally favorable for a heavy vegetative growth during the latter part of the season.

EXTENT OF SORGHUM-MIDGE DAMAGE DURING 1913 AND 1914.

The season of 1913 was very favorable for the production of grain sorghum. Although the rainfall was about 2 inches below normal, the crop did not suffer severely from drought. The crop was well past the flowering stage before the sorghum midge appeared in sufficient numbers to do serious damage. Consequently, the insect had very little, if any, effect on the yield, even of the later plantings.

On the other hand, the season of 1914 was particularly unfavorable. The spring was unusually wet and cool, and, owing to these conditions at and after planting time, such poor stands were obtained that it was necessary to replant twice, which made the crop so late in coming to flower that there was a rather severe infestation of the midge in all the plats. This late flowering afforded an opportunity for determining the effect on the yield of suppressing the tillers and branches.

Suppressing the tillers, and thereby causing the plant as a whole to flower more uniformly, was of little value as far as the sorghum midge was concerned in 1913, but in 1914 the yields were extremely low on the plats where the plants tillered and branched freely. These low yields were due entirely to the fact that the heads of all the tillers and branches were sterile, owing to the ravages of the midge.

RESULTS OF THE EXPERIMENTS.

Experiments were conducted at the San Antonio Experiment Farm in 1913 and in 1914 to determine the effect of planting milo in rows at different distances apart and of thinning the plants to different distances within the row on the tillering, branching, uniformity, date of ripening, and yield of grain. These experiments are reported and discussed in this bulletin.

EFFECT OF PLANTING ROWS AT DIFFERENT DISTANCES APART.

The different widths between rows were tested in one-fifth acre plats, the rows being 264 feet long. The plants within the rows stood approximately 5 inches apart on all the plats, except where the stand was somewhat reduced by imperfect germination. The average number of plants per row, of mature heads per row and per plant, and the yield per acre are given in Table II. In this table, as well as in the following tables, the number of mature heads per plant and per row includes the main stalks and tillers, but not the branches, which when given are in another column.

Table II.—*Results of planting milo in rows at varying distances apart at the San Antonio Experiment Farm in 1913 and 1914.*

Distance between rows.	Number of plants per row.	Number of mature heads—		Average number of branches per plant.	Heads pendent.	Yields per acre.
		Per row.	Per plant.			
In 1913:					*Per cent.*	*Bushels.*
36 inches	350	879	2.5			42.9
40 inches	405	899	2.2			45.8
44 inches	339	959	2.8			45.3
48 inches	459	1,155	2.6			46.2
In 1914:						
36 inches	478	508	1.06	0.22	4	25.3
39 inches	439	472	1.07	.41	9	24.9
42 inches	498	532	1.08	.45	9	23.6
45 inches	529	552	1.04	.64	9	18.6
48 inches	504	542	1.08	.50	7	16.1

As Table II shows, no very marked effects were produced on the number of heads per plant by varying the width between the rows. The differences in yield were small. The results of the 1914 tests were similar to those conducted in 1913, except that an extra plat was included, as shown in the table.

There was practically no difference in the number of heads per plant when the rows were spaced at different distances, nor was there any consistent variation in the number of branches or pendent heads, although there is a tendency for the number of branches to increase as the distance between the rows increases, as shown by the 1914 results. The yields, however, uniformly increased as the distances between the rows decreased. This was to be expected, as the season was so favorable as to rainfall that even with the rows 3 feet apart the plants did not suffer from the want of rain. This table indicates that varying the distance between the rows does not appreciably affect the tillering or branching. The distance between rows will have to be governed by local conditions. Where the soil is rich and the rainfall abundant, the rows may be much closer together than they otherwise should be planted.

EFFECT OF DIFFERENT SPACINGS WITHIN THE ROW.

In six plats on which milo was planted in rows 4 feet apart in 1913 the plants were thinned to 18, 12, 8, 5, and 2 inches, respectively, within the row, one plat being left unthinned as a check. All the plats were one-tenth of an acre in size except the one on which the plants were thinned to 5 inches; this plat contained one-fifth of an acre. The results of this test are given in Table III. The "perfect stand" has been calculated as the number of plants which each row would have contained if the stand had been perfect. The actual stand stated was the average number of plants per row as estimated by counting the plants in one representative row in each plat. The number of heads was obtained by actual count, using the same rows that were used in determining the stand.

TABLE III.—*Results of thinning milo plants to different distances within the rows, which were 4 feet apart and 264 feet long, at the San Antonio Experiment Farm in 1913 and 1914.*

Perfect stand.	Actual spacing.	Stand (plants per row.)		Number of mature heads [1]—		Average number of branches per plant.[2]	Heads pendent.[2]	Average height of plants.	Yield per acre.
		Perfect.	Actual.	Per row.	Per plant.				
In 1913:	*Inches.*						*Per ct.*		*Bushels.*
18 inches apart	20.2	176	157	814	5.2				42.5
12 inches apart	13.3	264	237	1,034	4.3				42.1
8 inches apart	10.5	398	293	1,066	3.6				43.8
5 inches apart	7.2	634	439	1,155	2.6				46.2
2 inches apart	3.8	1,584	833	1,209	1.5				46.4
Not thinned	3.5		895	1,169	1.3				46.4
In 1914:									
24 inches apart	24.5	132	129	393	3.04	3.44	49	4.8	1.2
18 inches apart	17.7	176	179	445	2.48	3.31	45	5.1	3.6
12 inches apart	12.7	264	254	375	1.48	2.64	32	5.5	6.6
8 inches apart	9.8	398	324	398	1.23	2.02	31	5.7	11.8
5 inches apart	6.3	634	504	541	1.07	.51	7	5.9	16.1
2 inches apart	3.5	1,584	902	936	1.04	.41	5	6.8	18.2
Not thinned	2.3		1,364	1,415	1.04	.31	.6	7.3	21.8

[1] Includes tillers and main stalks.
[2] Based on the counts from one row only. All other results are the average of four rows.

The most important fact shown in Table III is that the number of heads per plant decreased consistently as the spacing within the row decreased. The average number of heads per plant in the 18-inch spacing was 5.2, while in the 2-inch spacing it was only 1.5, a decrease of 3.7 heads per plant. The yield, however, increased slightly as the plants were crowded within the row; that is, the thicker stands produced the higher yields.

The results of the tests made in 1914 are essentially a duplicate of those in 1913, an extra plat being added in which the plants were thinned to 24 inches in the row. All the plats used in 1914 were one-twentieth of an acre in extent, except the one thinned to 5 inches between plants, which was one-tenth of an acre. Additional columns show the average number of branches, the percentage of pendent heads, and the average height of the plants.

In general, the results of the tests made in 1914 agree with those obtained the previous year. For instance, in the 5-inch planting the tillers per plant in 1913 averaged 2.6, whereas in 1914 the average was only 1.07, or less than in the unthinned plat in 1913. This was undoubtedly due to the seasonal conditions. The weather during April and May, 1914, was unusually wet and cloudy, during April especially so, while in 1913 the conditions were more nearly normal. Temperature and sunlight, it appears, have a very marked effect on the number of tillers that are produced.

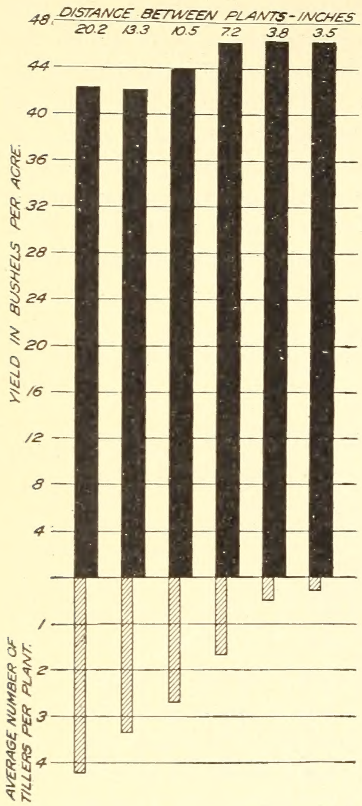

FIG. 1.—Diagram showing graphically the grain yields of milo and the tillers produced in the 1913 experiments. The solid columns indicate the yield in bushels, and the shaded columns represent the tillers.

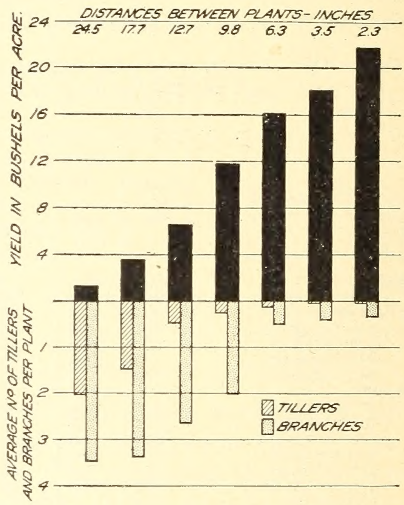

FIG. 2.—Diagram showing graphically the grain yields of milo and the tillers and branches produced in the 1914 experiments. The solid columns denote the yield in bushels, while the tillers are represented by diagonally shaded columns and the branches by dotted columns.

Another point brought out in the test of 1914, which was not noticeable the preceding year, was the branching of the plants, which took place after the warm weather set in. Counts were made of all the different plats at the time of ripening, and the number of branches averaged as high as 3.44 where the plants were spaced 24 inches apart. From this the number of branches decreased uniformly until there were only 0.31 per plant in the unthinned rows. It is probable that, as tillering did not take place until the plants were well along in growth and as there was an abundance of moisture in the soil, the plants spaced to a greater distance than 5 inches offset this wide spacing by sending out branches.

That the wider spacing in the rows increased the number of pendent heads is also brought out. The percentage of pendent heads increased from 0.6 per cent in the plat not thinned to 49 per cent in the plat where the plants were spaced to 24 inches apart.

It is evident that the yields from the plats in which the plants were spaced 12, 18, and 24 inches apart in the 1914 experiments were much lower than would be expected if the midge damage was uniform in the heads of the main stalks. Observations made at the time the heads were maturing showed that the damage by this insect in the three plats mentioned was much more severe than on the plats where the plants were spaced less than 12 inches apart in the row. It should be understood that this does not refer to the tillers or branches, for in no case, even on the plats where the plants were closely spaced in the row, did over 5 per cent of the seed set. The four rows of the plat where the plants were spaced 12 inches apart were located beside the four rows of the plat thinned to 2 inches apart, so that they were as nearly as possible on an equal footing, and there was no apparent cause for a greater midge infestation in one than in the other. The date of flowering of the main stalks was practically the same in both cases.

The effect of varied spacing on the yield and the production of tillers and branches is shown graphically in figures 1 and 2.

EFFECT OF ROW WIDTH AND SPACING ON TILLERING AND HEAD PRODUCTION.

On May 15, 1913, counts were made of the number of stalks per row and per plant on the plats already discussed. These counts were made when the plants were about 18 inches high. At harvest time the number of heads per plant on the same plants counted May 15 was determined. The results of these counts are given in Table IV.

TABLE IV.—*Stalks and heads per row and per plant on May 15 and at harvest time on nine plats of milo planted at different widths and spaced differently at the San Antonio Experiment Farm in 1913.*

Distance between rows.	Spacing.	Number per row.			Number per plant.	
		Plants.	Stalks, May 15.	Heads at harvest time.	Stalks, May 15.	Heads at harvest time.
	Inches.					
48 inches	(1)	895	2,601	1,169	2.9	1.3
48 inches	2	833	2,357	1,209	2.8	1.5
48 inches	5	439	2,198	1,155	5.0	2.6
48 inches	8	293	1,611	1,066	5.5	3.6
48 inches	12	237	1,504	1,034	6.3	4.3
48 inches	18	157	1,050	814	6.7	5.2
44 inches	5	339	1,950	959	5.7	2.8
40 inches	5	405	1,573	899	3.9	2.2
36 inches	5	350	1,753	879	5.0	2.5

1 Not thinned.

Table IV shows that there was a marked decrease in the number of stalks per plant where the plants were crowded. From the yields obtained on these plats, particularly those shown in Table II, it appears that this reduction of tillering is advantageous from the standpoint of crop returns. As shown in Table IV, a large number of the stalks found on May 15 failed to mature heads. The production of nonbearing stalks or tillers uses soil moisture without any compensatory results. This being true, it seems desirable to reduce

FIG. 3.—Close-spaced milo plants, showing almost total freedom from tillers and the resulting high uniformity. (Photographed June 4, 1913.)

the number of stalks per plant, and it appears that this can be readily done by crowding the plants within the row, as is shown in figures 3, 4, 5, and 6.

EFFECT OF SPACING ON MATURITY.

One of the most important requirements for the successful production of grain sorghum in the San Antonio region is early and uniform maturity. This is necessary, in order that the crop may escape the ravages of the sorghum midge.

In the experiments conducted in 1913 a part of a row containing 50 plants was laid off on each of the six plats where the rows were 4 feet apart and where the spacing distances were varied. These plants were tagged and the date of maturity of each head was noted. Observations were made every two or three days during the ripen-

FIG. 4.—Milo plants thinned to 2 inches apart, showing the erect heads and the plants free from tillers and branches. Very little midge damage was done to the rows where the tillers and branches were suppressed by close spacing. (Photographed July 15, 1914.)

ing season. The results of these observations are given in Table V. The number of heads per plant of the 50 plants observed in each plat in this distance, as shown in the third column, is slightly different in some cases from the estimate made to represent the entire plat, as shown in Table III, but the general relationship between the spacing of the plants and the number of heads per plant remains unchanged.

FIG. 5.—Wide-spaced milo plants, showing excessive tillering and lack of uniformity in heading and ripening. The seed is set on the main stalk, while on some of the tillers the heads are just beginning to flower and on others the heads are just emerging from the boot. (Photographed June 4, 1913.)

TABLE V.—*Heads of milo matured on different dates in six plats, where the plants were spaced differently, the percentages being based on actual counts of 50 plants in each plat, at the San Antonio Experiment Farm in 1913.*

Spacing.	Number of heads—		Percentages of mature heads.							
			June.					July.		
	On 50 plants.	Per plant.	21	24	26	28	30	2	5	8
Plats considered separately:										
Not thinned	63	1.2	62	75	87	88	89	95	100	......
2 inches apart	78	1.5	60	79	91	91	92	95	98	100
5 inches apart	177	3.5	11	31	46	60	65	78	92	100
8 inches apart	174	3.5	14	34	46	54	65	82	94	100
12 inches apart	234	4.6	19	43	59	68	82	95	99	100
18 inches apart	231	4.6	13	43	53	67	83	97	99	100
Plats averaged in pairs:										
Not thinned and 2 inches apart	70	1.3	61	77	89	89	90	95	99	100
5 and 8 inches apart	175	3.5	12	32	46	57	65	80	93	100
12 and 18 inches apart	231	4.6	16	43	56	67	82	96	99	100

As shown in Table V, about 60 per cent of the heads on the close-spaced plants (unthinned and 2-inch spacing) ripened before June 21, and five days later practically 90 per cent of the heads on these plants were ripe. The ripening period, therefore, was approximately one week. On the other hand, only 11 to 19 per cent of the heads on the wider spaced plants (the spacings varying from 5 to 18 inches) ripened

FIG. 6.—Milo plants, spaced 24 inches apart, showing that when thus widely spaced practically all of the plants had one or more tillers and all branched freely. (Photographed July 15, 1914.)

before June 21, and on June 26, when about 90 per cent of the heads on the close-spaced plants were ripe, only about 53 per cent of the heads on the wider spaced plants had ripened. The ripening period of the heads on the wider spaced plants was about two weeks, or twice as long as that of the heads on the close-spaced plants. The earlier and shorter ripening period is a distinct advantage, particularly in allowing the crop to escape midge injury. It is evident, therefore, that in this connection, as well as in regard to crop yield, the thicker stands produced the best results.

A special point in connection with the maturing period of the differently spaced plants is that the plants in the six spacings fall into three distinct classes, based on time of maturity. In order to show this clearly, the lower part of Table V was compiled from the data in the upper part of the same table. The unthinned plants and those spaced to 2 inches are considered together as one class, those spaced to 5 inches and those spaced to 8 inches are considered as a second class, and the plants spaced to 12 and 18 inches are considered as a third class. The figures given are the averages of two spacings in each instance.

As already pointed out, the heads on the close-spaced plants ripened earlier than those on the plants spaced to 5 or more inches, but the table shows that the earliness was not proportionate to the closeness of spacing throughout the six plats. The unthinned plants and those spaced to 2 inches matured their seed at practically the same time; the widest spaced plants, 12 and 18 inches, came next in time of maturity; and the plants in the intermediate spacings, 5 and 8 inches, ripened last. This was probably due to the relative favorableness to tillering and to head production by the tillers resulting from the different spacings. The close-spaced plants produced very few tillers and the heads on the main stalks grew up and ripened promptly and uniformly; the widest spaced plants had the best conditions for tillering and the heads on the tillers had a fairly good opportunity to develop; but the plants spaced to intermediate distances, while producing a relatively large number of tillers, were sufficiently crowded to make it difficult for the heads on the tillers to reach maturity.

While the widest spaced plants matured earlier than those spaced to intermediate distances, and in this respect produced more favorable results, it is likely that the stumps left after harvest would be larger on the widest spaced plants, and this would be a serious objection, as is pointed out later. Considering the entire series, the results obtained with the closest spacing show that thicker seeding is much to be preferred.

In the results obtained in the 1914 test, as is indicated in Table III, giving the yields, none of the tillers or branches produced seed. There was a rather severe infestation of the field with midges at the time the first heads (main stalks) were in flower, so that when the later heads (branches and tillers) flowered, the field was so badly infested that the heads were practically sterile.

As is shown in Table III, close spacing resulted in only a slight increase in the number of stalks per row over the number produced by wide spacing, up to 12 inches. Table VI, a comparison of the 1913 results of the 12-inch spacing and of the rows in which the plants were not thinned, shows this condition.

TABLE VI. *Plants and heads of milo in rows differently spaced at the San Antonio Experiment Farm in 1913.*

Spacing.	Number per row.	
	Plants.	Heads.
Not thinned	895	1,169
12 inches apart	237	1,034
Difference	658	135

Table VI shows that while the number of plants per row in the unthinned rows exceeded by 658 that of the rows in which the plants were 12 inches apart, the number of heads per row differed by only 135. This difference in the number of heads per row is seen to be very slight when it is considered that the rows were 264 feet long. Consequently, when seeds are so placed as to have the plants 6, 8, or 12 inches apart in the row, with the idea that less moisture will be required to mature the crop, the grower may actually obtain as many heads per row as would result from thicker seeding, and he may find that the moisture requirement has not been reduced at all. Furthermore, the thin seeding, by promoting tillering, would delay maturity.

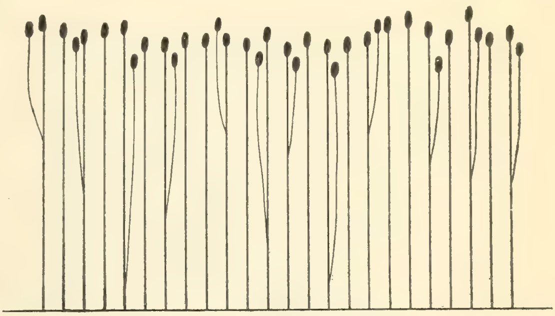

FIG. 7.—Diagram showing the appearance of milo plants when spaced closely together.

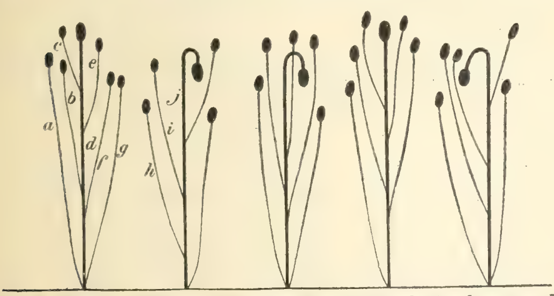

FIG. 8.—Diagram showing the appearance of milo plants when spaced 12 inches apart: *a* and *g*, Tillers; *d* and *j*, main stalks; *b*, *c*, *e*, *f*, *h*, and *i*, branches.

Figures 7, 8, and 9 illustrate this. These diagrams were made up from Table III. Figure 7 shows the spacing of the plants in the plat not thinned. Figure 8 shows the spacing of the plants and the tillers and branches in the plat thinned to 12 inches. Figure 9 is made up from figure 8; that is, it shows how the row would appear if the tillers and branches were removed and placed between the main stalks, and it should be compared with figure 7. It will be seen that in reality there are nearly as many stalks per row in the 12-inch planting as in the plat not thinned. The actual counts show that the plants in the unthinned plat average 2.3 inches apart. Assuming that the tillers and branches were plants in the plat thinned to 12 inches, the plants would then average 3 inches apart, or only 0.7 of an inch farther apart than the plants in the unthinned plat.

The rainfall at the San Antonio Experiment Farm from the planting time to the ripening period of the milo in the 1913 experiments was about 2 inches below normal. This condition was particularly favorable for comparing the results obtained from different plant spacings. These results, together with numerous observations made in previous years, both at the experiment farm and on other farms in the region, indicate that relatively close spacing within the row is preferable to wide spacing, even when the rainfall of the growing season is relatively low. The results of the experiments indicate that the plants should be approximately 3 or 4 inches apart within the row.

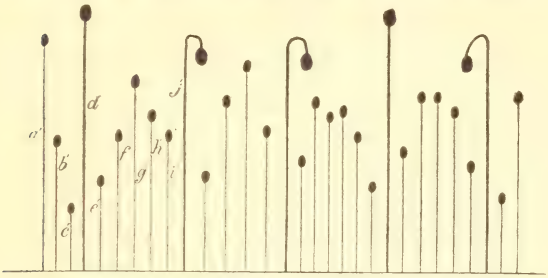

FIG. 9.—Diagram made up from figure 8, showing the branches and tillers removed and placed between the milo plants: *a'* and *g'*, Tillers; *d* and *j*, main stalks; *b'*, *c'*, *e'*, *f'*, *h'*, and *i'*, branches.

VARIATIONS IN TILLERING.

There is a marked difference in the amount of tillering in the two years that the test has been carried on. (See figs. 1 and 2.) For the purpose of comparison, Table VII has been included.

TABLE VII.—*Tillering of milo plants differently spaced in rows 264 feet long at the San Antonio Experiment Farm in 1913 and 1914.*

Perfect stand.	Actual spacing (inches).		Stand (plants per row).		Number per plant.					
					Mature heads.		Branches.		Branches and tillers.	
	1913	1914	1913	1914	1913	1914	1913	1914	1913	1914
24 inches apart	....	24.5	....	129	....	3.04	....	3.44	....	5.48
18 inches apart	20.2	17.7	157	179	5.2	2.48	....	3.31	4.2	4.79
12 inches apart	13.3	12.7	237	254	4.3	1.48	....	2.64	3.3	3.12
8 inches apart	10.5	9.8	293	324	3.6	1.23	....	2.02	2.6	2.25
5 inches apart	7.2	6.3	439	504	2.6	1.07	....	.51	1.6	.58
2 inches apart	3.8	3.5	833	902	1.5	1.04	....	.41	.5	.45
Not thinned	3.5	2.3	895	1,364	1.3	1.04	....	.31	.3	.35

The most striking difference in the 1913 and 1914 results is in the reduction of the number of tillers in 1914 and the appearance of branches, which did not occur the previous year. However, in the wider spacings the total number of branches and tillers is about equal to the total number of tillers alone in 1913. In the close spacing there was a decidedly smaller number of tillers and branches combined than in 1913. This variation is unquestionably due to the rather unusual weather conditions during the months of April and May, 1914. The weather conditions for the first six months of each year and the averages, as given by the United States Weather Bureau for a number of years, are shown in Table VIII.

TABLE VIII.—*Aspect of the sky, temperature, and rainfall at San Antonio, Tex., for the first six months of the years 1913 and 1914, showing also averages for stated years.*

Month.	Aspect of sky.									Temperature (° F.).									Rainfall (inches).		
	Days clear.			Days partly cloudy.			Days cloudy.			Mean maximum.			Mean minimum.			Mean.					
	Av.[1]	1913	1914	Av.[1]	1913	1914	Av.[1]	1913	1914	Av.[1]	1913	1914	Av.[1]	1913	1914	Av.[1]	1913	1914	Av.[2]	1913	1914
January	10.6	9	24	9.5	9	4	10.8	13	3	63.1	62.1	68.4	42.6	42.7	44.4	52.8	52.4	56.4	1.32	0.96	0.09
February	9.6	11	10	8.3	11	8	10.3	6	10	65.4	62.1	63.5	44.4	42.0	42.8	54.8	52.0	53.2	1.71	1.91	1.38
March	9.6	18	17	10.5	9	6	10.9	4	8	73.7	70.8	69.9	52.1	47.9	47.8	62.9	59.4	58.8	1.75	1.36	.83
April	8.2	16	13	11.6	9	5	10.5	5	12	79.8	79.1	77.8	58.8	54.7	55.8	69.2	66.9	66.8	2.69	1.32	5.26
May	8.0	20	4	11.3	9	16	8.0	2	11	85.1	87.1	82.3	65.3	64.1	66.4	75.1	75.6	74.4	3.04	2.88	5.59
June	----	---	---	----	---	---	----	---	---	91.2	88.3	91.2	70.8	70.2	72.8	80.9	79.2	82.0	2.62	2.90	.01
Total	----	---	---	----	---	---	----	---	---	----	----	----	----	----	----	----	----	----	13.13	11.27	13.16

[1] Average for the years 1877 to 1913. [2] Average for the years 1871 to 1913.

While Table VIII shows no great variation in the temperature during the growing months, there was an unusual difference in the aspect of the sky for the months of April and May, the months when most of the tillers and branches were being formed. For example, there were three more clear days in April and sixteen more in May in 1913 than in 1914. There were over twice as many cloudy days in April and over five times as many in May in 1914 as in the same months of the previous year. It is certain that light has a very marked effect on the development of tillers, and the only reasonable explanation to be offered in the variation in tillering during the two years seems to be a corresponding variation in light, as the soil conditions were very similar. There was a much greater rainfall in 1914 than in 1913 during the months of April and May, as is shown, but this, if it would influence the results in any way, would be likely to make conditions more favorable for tillering. It would seem, on the whole, that an intermediate between the two seasons is much nearer the mean than either of the two seasons during which the experiments have been conducted. It is reasonable to conclude that in most seasons tillering might be somewhat less than in 1913, but much greater than in 1914, especially in the closer spaced plantings. Branching before the plants mature is abnormal and rarely occurs to any appreciable extent in grain sorghums at San Antonio.

THICK SEEDING AND THE SIZE OF PLANT STUMPS.

Another advantage derived from seeding thicker than is customary is the reduced size of the plant stumps. One of the objections advanced against the growing of grain-sorghum crops, particularly in the black lands of Texas, is the difficulty of preparing the land for the succeeding crop. Where the plants grow very large the increased size of the rooting system necessary to support a plant with several stalks often causes soil to adhere to the roots, forming large masses of mixed roots and soil. When the land is plowed, many of these large clods, which are very difficult to turn under, are left on the surface, greatly increasing the difficulty of properly preparing the seed bed. Thicker seeding, by reducing the size of individual plants, markedly lessens this difficulty.

THICK SEEDING AND CROP STANDS.

It is obvious that the best results can not be secured with milo where the stand is irregular and spotted. Where relatively thin seeding is practiced the chances of getting a good, uniform stand are reduced. There are numerous conditions that operate to prevent high germination of the seed and successful growth of the crop, and, within reasonable limits, thick seeding is desirable, as it increases the chances of securing a good stand in spite of adverse conditions of soil and climate. There is little danger of getting the milo plants too close together in the row so long as the rate does not greatly exceed 5 pounds of seed per acre, the rate used in these experiments, with rows 4 feet apart. As is shown in Table III, the highest yields were obtained from the unthinned rows and the 2-inch spacing. In 1913 both these plats yielded at the rate of 46.4 bushels per acre. In 1914 the two plats so spaced yielded at the rate of 21.8 and 18.2, bushels, respectively. It seems certain that to secure satisfactory stands it is desirable to plant at a rate at least as high as 5 pounds of seed per acre. This would make a rather thick seeding if every seed produced a plant, but this is seldom the case. The experiments carried on with milo at San Antonio have shown that if the planter plates are so arranged that only one seed is dropped where a plant is desired, such a poor stand will generally result that the yields will be very materially decreased. In the experiment described above, with a seeding rate of 5 pounds per acre, if every seed had produced a plant the plants would have averaged about 1.5 inches apart, or 2,112 plants to a 264-foot row. But, as is shown in Table III, there were only 895 mature plants per row in the plat that was not thinned.

THICK SEEDING AND MATURITY.

It has already been shown that the closer spaced plants matured earlier and more uniformly than those which were farther apart in the row. As shown in Table V, the difference in earliness of maturity was approximately one week. This is of profound importance in escaping injury from the sorghum midge. It has been found at the San Antonio Experiment Farm that a few days' delay in the time of flowering may result in the almost complete destruction of the crop by this insect. This is strongly emphasized in the 1914 results. Thick seeding, then, by insuring that the plants will be close together within the row, is favorable in its effect upon the maturity of the crop.

THICK SEEDING AND CROP YIELD.

From what has been stated about the favorable effect of thick seeding upon the stand and maturity of the crop, it would be expected that the yield would be favorably affected also. This expectation was fully realized in the 1913 experiments and strongly emphasized again in the 1914 experiments, as indicated in Table III, which shows that the yield increased consistently as the spacing of the plants within the row decreased from 24 inches to 2 inches.

THICK SEEDING AND RAINFALL.

It has been supposed by many that the rate of seeding of grain crops should always be greatly decreased in regions of low rainfall. This supposition is probably not always well founded, because most grain crops tend to offset thin seeding by tillering. Early and uniform ripening is frequently of great importance in dry regions, because it assists the crop in evading midseason droughts and also, in many cases, in escaping insect injury. It seems that thin stands promote excessive tillering of milo, with resulting lateness and lack of uniformity in ripening. (See figs. 5 and 6.) It has also been shown in Table II that increasing the distance between rows has little, if any, effect on the production of tillers. It seems, therefore, that where the question of moisture is an acute one, the conditions should be met by increasing the distance between the rows rather than that between the plants within the row.

If the moisture supply could be controlled so that it would be uniform from year to year, there is a certain distance apart that the rows might be planted to get the maximum yield, which in no way has any connection with the distance apart of the plants within the row, even where the rainfall is limited. Large plants with several tillers may actually suffer more during a dry period than several plants each with only a single stalk occupying the same space, because where each stalk has its own rooting system it can use the moisture more effectively.

TIME OF THINNING.

For the purpose of determining the effect of thinning to 12 inches apart at various dates on the number of tillers and branches, a small area was devoted to this test. The rate of seeding used in this test was the same as in the other experiments, so that the average distance between the plants before thinning was slightly over 2 inches. Owing to the smallness of the area the yields were not measured, and as there were only two rows in each plat in the center of the field it is probable that the behavior of the plants in this test was influenced to some extent by adjoining rows. Table IX gives the total number of plants considered and the average number of mature heads and branches per plant.

TABLE IX.—*Heads and branches of milo plants, showing the effect of thinning at various dates at the San Antonio Experiment Farm in 1914.*

Date thinned.	Number of plants.	Number per plant.	
		Mature heads.	Branches.
May 12	58	1.26	0.43
May 25	84	1.19	.23
June 2	73	1.13	1.00
June 9	70	1.03	1.30

While the difference between the first and last thinning is not great, there is a fairly consistent variation. There is a gradual decrease in the number of mature heads from the first to the last thinning date, but the reverse is the case with the number of branches, as they increase as the date of thinning is delayed. This is to be expected, for, as has been shown in previous tables, the 12-inch spacing between plants is so wide that they will send out either tillers or branches to offset it. Where thinning is delayed long enough to allow the plants to become of sufficient size to largely prevent tillering, as was the case with the June thinnings, branches will be produced if the conditions during the later part of the season are sufficiently favorable.

While, as already intimated, too much importance should not be given to the data in this table, the results are in accord with the previous experience of the writer and indicate that the time of thinning is not of great importance if it is done early enough to avoid injury to the adjoining plants. If the thinning is done when the plants are very small, there may be produced a considerable number of tillers, a very small percentage of which will not develop, owing to crowding later in the season. This is shown where counts were made early in the season and at ripening time (Table V, p. 10). In the field plantings on the experiment farm during the last two years it was found to be unnecessary to do much thinning. In 1913 the time consumed in thinning the field plantings was not greater than was necessary to thin corn, where the plants were thinned to 2 feet apart in the row. No thinning was necessary in 1914. In both years the rows were 4 feet apart and about 5 pounds of seed to the acre were planted.

ADVANTAGES OF THICK SEEDING.

In the foregoing discussion reference has been made to close spacing and wide spacing rather than to thick seeding and thin seeding. This terminology has been used because it conforms to the methods used in the experiments reported. For convenience in securing accurate counts and measurements, it was thought desirable to plant all the plats at the uniform rate of 5 pounds of seed to the acre, although it was necessary to replant twice in 1914, using a heavier rate. This is a relatively thick seeding if conditions are favorable. The plants were then thinned to varying distances within the rows to correspond approximately to the stands which would result from various rates of seeding. In actual practice the stand is regulated by varying the rate of seeding, as it is not generally considered practicable to thin the plants in a large field. The close spacing which seems to be desirable must be secured by relatively thick seeding.

The results obtained from the tests covering two years show clearly two things: (1) That even in favorable seasons when the midge is not a factor the yields are not decreased by thick seeding and (2) that in years when the midge appears at about flowering time the yields are very materially increased when the tillers and branches are suppressed by thick seeding.

From even the purely theoretical standpoint, where no other factors are involved, it would seem that if a tiller is given a root of its own it will do better than when several heads are dependent upon a single rooting system, which is indicated in the results obtained in 1913. In other words, when earliness is not a factor, the yields are not decreased when the tillers are suppressed. In fact, the weight of evidence indicates that the thicker seedings are better.

THICK SEEDING IN OTHER SECTIONS.

It is appreciated that the number of tillers produced depends, aside from the spacing of the plants in the row, upon the productivity of the soil and upon the climatic conditions. Where the conditions vary considerably from those at San Antonio it is realized that the results would doubtless vary greatly with similar experiments. This does not in any way affect the value of these results nor prohibit the application of the principle, but simply shows the necessity of conducting experiments to determine the proper spacing of the plants in the row and the distance between rows for the locality.

Aside from the data herein given, very little information is available relative to the effect of various spacings on the behavior of grain-sorghum crops. That other factors are involved besides the available moisture supply seems not to have been recognized. Fragmentary statements are found here and there in various publications which have intimated that where thin rates of seeding were made the plants have stooled or tillered sufficiently to seemingly offset the thin stand. This tillering habit has been frequently referred to as desirable. It is yet to be proved that thin seeding, with its attendant heavy tillering, will anywhere give a heavier grain yield than a thicker seeding which largely prevents tillering. The chief advantage, if not the only one, derived from tillering seems to be that where, owing to unfavorable conditions at the time of planting, a poor stand is secured, tillering tends to offset this and the yield of grain is generally, although not always, increased. The logical conclusions, in the light of the experiments cited in this bulletin, indicate that the rate of seeding should be heavy enough to prevent tillering.

SUMMARY.

(1) Experiments conducted at the San Antonio Experiment Farm since 1909 and observations made on other farms in the vicinity show that grain sorghum can be made a very satisfactory grain crop for the region if the proper varieties are grown and the necessary cultural methods are followed.

(2) One of the chief reasons for unsatisfactory yields appears to be the poor stands which frequently result from thin seeding. Poor stands result in late and nonuniform maturity and low yields, particularly when delayed maturity subjects the crop to the depredations of the sorghum midge.

(3) Experiments with milo were conducted at the San Antonio Experiment Farm in 1913 and 1914 to determine the effect of planting in rows at different distances apart and of thinning the plants to different distances within the rows on the tillering and branching, the uniformity and date of ripening, and the yield.

(4) No marked differences resulted in the number of tillers or the number of heads per plant from varying the distance between rows.

(5) In the plats where the rows were uniformly 4 feet apart, but where the plants were thinned to different distances within the rows, the number of heads per plant decreased and the yield increased as the plants were crowded, the thicker stands producing the higher yields.

(6) Counts made of the number of tillers per plant on May 15 and of the number of mature heads per plant at harvest showed that a large number of tillers on the wide-spaced plants failed to produce heads.

(7) The close-spaced plants ripened their grain in 1913 about one week earlier than the wide-spaced plants. This early maturity is particularly important in that it permits the crop to escape the sorghum midge.

(8) Increasing the number of plants per row does not necessarily mean a proportionate increase in the total number of heads or stalks per row.

(9) The weather conditions influence very markedly the number of tillers and branches produced, although the total number of branches and tillers produced in 1914 about equaled the total number of tillers alone in 1913, when there were but few branches.

(10) In practice, the stand is controlled by varying the rate of seeding rather than by thinning the plants; thick stands are secured by thick seeding.

(11) Thicker seeding than is ordinarily practiced appears to be desirable, in that it results in smaller and more easily handled plant stumps, gives better stands, insures earlier and more uniform maturity, and produces better yields. A rate of 5 to 6 pounds per acre, where the rows are 4 feet apart, is recommended.

(12) It would appear that the close spacing of the plants can be practiced in sections of low rainfall. To offset this increase in the number of plants per row it is necessary only to increase the distance between the rows.

(13) The time the plants are thinned does not seem to be an important factor in suppressing tillers and branches. If the thinning is delayed sufficiently to reduce tillering, there seems to be a tendency for the plants to increase the number of branches.

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